Alpha decay of ^{227}U and excited levels in ^{223}Th studied at SHIP*

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Alpha decay is a valuable tool to investigate nuclear structure. Analyzing α-γ coincidences, one can localize energy levels in daughter nuclei populated by α decays of parent isotopes. Information of level ordering and placement helps to optimize theoretical nuclear models, which improve our understanding of basic processes in atomic nuclei.

The excited levels in ^{223}Th were studied for the first time in an in-beam measurement in Heidelberg (Germany) already more than 20 years ago [1]. Short time after that, also an out-of-beam study was performed in Louvain-la-Neuve (Belgium), where ^{223}Th was produced by the α decay of ^{227}U [2]. Different levels in ^{223}Th were populated in each of those studies.

We studied the levels in ^{223}Th in an experiment performed at GSI in April 2014. The levels were populated by the α decay of ^{227}U produced in the fusion-evaporation reaction ^{22}Ne + ^{208}Pb. The beam energy was 104 MeV in front of the target. The nuclei of interest were separated from other particles by the velocity filter SHIP and implanted into a focal-plane detector arrangement. A 16-strip position-sensitive silicon detector registered α-decay signals and a germanium clover detector placed close behind the silicon detector registered γ rays.

To avoid admixtures of decays of other isotopes in our analysis, we applied strict conditions on parent, daughter and granddaughter decays. We searched for correlated $\alpha 1(^{227}\mathrm{U})$-$\alpha 2(^{223}\mathrm{Th})$-$\alpha 3(^{219}\mathrm{Ra})$ chains. We accepted position differences of subsequent decays smaller than 0.4 mm and time windows were set to be 90 ms $< \Delta t(\alpha 1\text{-}\alpha 2) < 3$ s and 0.5 ms $< \Delta t(\alpha 2\text{-}\alpha 3) < 50$ ms. During the irradiation time of about two days, we collected in total approximately 50000 nuclei of ^{227}U implanted into the silicon detector.

The detection of $\alpha 1$-γ coincidences within a 5-μs time window (see Fig. 1b) allowed us to associate the α decays of ^{227}U with the corresponding levels in ^{223}Th. Based on the analysis of experimental and theoretical conversion coefficients, we assigned tentative characters to observed γ transitions. Consecutively, the improved decay scheme of ^{227}U-^{223}Th was obtained. As an extension to the previous out-of-beam study [2], we identified a new level at 370 keV in ^{223}Th. The weak lines at 396 and 489 keV can also be tentatively assigned to ^{223}Th. In order to verify the suggested decay scheme, we performed Monte-Carlo simulations using the toolkit Geant 4 [3]. Fair agreement was achieved between the simulation and experimental data (see Fig. 1a). More details will be given elsewhere [4].

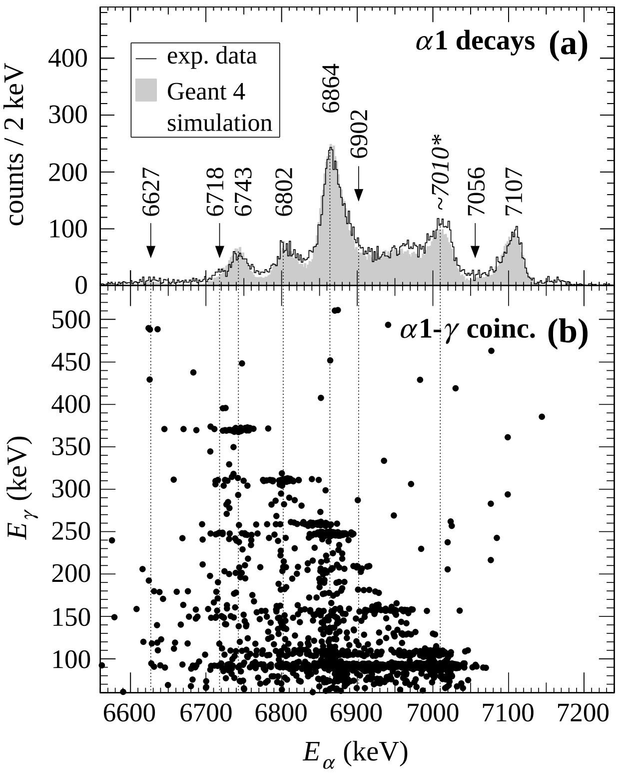

Figure 1: (a) Experimental energy spectrum (black solid line) of $\alpha 1$ decays extracted from the $\alpha 1$-$\alpha 2$-$\alpha 3$ correlation search measured in the focal-plane silicon detector. The shaded area represents the Monte-Carlo simulation of the decay of ^{227}U performed by Geant 4 [3]. A peak at ~ 7010 keV marked by an asterisk does not correspond to an α line of ^{227}U, but is created by the summing of α-particle and conversion-electron energies. (b) Spectrum of $\alpha 1$-γ coincidences showing γ rays detected within a time window of 5 μs after the $\alpha 1$ decays from (a).

References

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